Development of a UAV-Enabled Global Observation Network

Eric Frew
University of Colorado
Eric.Frew@Colorado.edu
(303) 735-1285

John Sharkey
NASA/DFRC
John.P.Sharkey@nasa.gov
(661) 276-3965

Strategic Focus Areas:
8. Exploration of the dynamic Earth system. 10. Advanced Aeronautical Technologies:

Statement of Need:
To meet the research and operation needs of the climate and weather science communities, NASA should take a leadership position in the development and deployment of a global Earth observation system comprising the multi-functional integration of space, airborne, land, and sea observational platforms. A critical, yet missing, component of this emerging global observation system is a networked grid of sub-orbital, long-duration atmospheric observation platforms to fill the data void over the oceans, poles and under-developed countries. The emergence of networked, autonomous, long duration Unmanned Aerial Vehicles (UAVs), capable of operating from the earth surface boundary layer to the tropopause, presents the opportunity to fill the existing data void and capability gap in the global observation system.

Relationship to National Priorities:
A UAV-enabled global observation network ties directly to national priorities concerning climate and weather research, including the observational core approach defined within the Climate Change Science Program (CCSP); the suborbital platform elements identified in the (draft) Strategic Plan for the U.S. Integrated Earth Observation System; and as prescribed within the Research and Development (R&D) investment guidelines from the Office of Science and Technology Policy (OSTP). *This input to the NASA Strategic Roadmap captures recommendations from 2 recent workshops comprising more than 80 lead scientists, engineers and managers from NASA, NOAA, DOE, academia and industry.*

Performance Capability Objectives:
The following items capture the key performance capabilities envisioned for the UAV segment of the global observation network:

- A sustained, grid-based network of high, medium, and low altitude UAV platforms, capable of measuring vertical profiles (0 – 65,000+ feet) of atmospheric state properties, aerosols, trace gases, and cloud radiative and optical properties;
- Routine vertical profile observations of 200-400 grid points over the oceans and poles on 48-72 hour intervals, over a multi-decade period of observation;
- Networked platform operations and data systems integrated with complimentary existing and emerging ground, sea, and satellite observation platforms;
- Safe, reliable, durable, and affordable operations within the global airspace;
- Flexible, adaptable observations capable of worldwide deployment;
- Highly integrated and optimized suites of atmospheric instrumentation systems.

Technology Gaps:
The major technology gaps obstructing the achievement of the capability objectives include:

- Global over-the-horizon and networked communication systems for the command and control of the sub-orbital components of the global observation system as well as the dissemination of acquired data;
- Sensors optimized for the size, power, and cost constraints of UAV operations;
- Durable UAV platforms suitable for all weather operations, particularly high-winds and icing conditions;
- Efficient propulsion and power generation for long-duration operations;
- Robust onboard flight management systems for increased autonomy through situational awareness, fault tolerance, and dynamic mission planning.

Suggested Development Approach:
A joint NASA-NOAA-DOE planning team should be established to conduct comprehensive systems analyses and trade studies in FY05-FY06, resulting in detailed system requirements, concepts of operation, and conceptual designs for an operational global observation system capability in 2015. An optimal mix of platforms, e.g. high altitude long endurance (HALE) and small low altitude short endurance (LASE) UAVs, along with piloted platforms and balloons, should be identified as each provides unique capabilities and opportunities. Collaborative UAV mission demonstrations, including integration with existing satellite and ground systems, should be performed by the joint planning team by leveraging existing program opportunities over this same timeframe. The development of new platforms and systems will require budget augmentations in FY07, leading to a multi-agency new initiative in FY08. A proof of concept mission is envisioned in the FY08-FY10 timeframe, leading to formal SRR/PDR/CDR control gates during FY11-FY12 for the operational system. These efforts must be coordinated with other national agencies and international partners to reduce overlaps and to leverage planned development opportunities.

Potential Benefits:
The UAV segment of the global observation network will provide the missing link between existing surface and space-based platforms, helping to capture the benefits of the CCSP. Using HALE UAVs as “atmospheric satellites” also has the potential to reduce life cycle costs by at least 50% over traditional satellite solutions for some future CCSP and IWGEO observation programs. HALE UAV “pseudo-satellite” platforms can also reduce program risk for future earth observing satellite programs, while providing affordable instrument testbed platforms for university research to accelerate graduate student completion rates.

Relationship to Existing Programs:
The proposed development is an extension of the NASA Vehicle Systems and Suborbital Science programs. However, the development of the integrated systems capabilities required for the UAV segment of the global observation system goes well beyond the scope, boundaries and budget of these existing efforts. There is also strong correlation with the DARPA J-UCAS program for development of a common UAV operating system.

Relationship to the Exploration Vision:
Several technologies developed to enable the UAV segment of the global observation system will also serve as stepping stones towards space exploration, including low Reynolds number airframes for planetary flight vehicles, electric propulsion, intelligent mission management and networked collaborative science platforms.